

Mr. W. H. Power's Report to the Local Government Board on Epidemic Prevalence of Diphtheria in North London.

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THIS Report relates to an epidemic of diphtheria during the spring of the present year in Kilburn and St. John's Wood in the sanitary districts of Hampstead and Marylebone. In the course of last May representations were made to the Board by certain medical practitioners of these districts that there was an unusual and increasing prevalence of diphtheria among their patients, and I received instructions to inquire into the facts. Putting myself in communication with these gentlemen, with the local medical officers of health and with other medical practitioners, I have been enabled to gather much and exact information as to the households invaded; and in the various directions my inquiry has taken, I have received valuable assistance from a large number of people, particularly from Dr. Morton of Kilburn. Primarily the Report will be concerned with a circumscribed area in the neighbourhood of Kilburn and St. John's Wood, near the junction of the above parishes, where the disease attained its chief prevalence; but inquiry has been pushed beyond that area, and indeed beyond the northern limits of the metropolis, with the result of obtaining important evidence bearing on the cause of the epidemic.

The following table, compiled from the weekly returns of the Registrar General, shows the prevalence of fatal diphtheria in groups of the metropolitan districts during each of the first 26 weeks of the year. A distinct increase in the mortality will be observed in the second quarter as compared with the first. A very important share of the increase is borne by the northern group of districts which includes the Hampstead and Marylebone parishes. It was in May that this increase took place.

TABLE I.
DEATHS FROM DIPHTHERIA, METROPOLITAN DISTRICTS, 1878.

Week ending	WEST. Population 1871, 561,359.	NORTH. Population 1871, 751,729.	CEN-TRAL. Population 1871, 334,369.	EAST. Population 1871, 639,111.	SOUTH. Population 1871, 967,692.	WHOLE METRO-POLIS. Population 1871, 3,254,200.	Week ending	WEST. Population 1871, 561,359.	NORTH. Population 1871, 751,729.	CEN-TRAL. Population 1871, 334,369.	EAST. Population 1871, 639,111.	SOUTH. Population 1871, 967,692.	WHOLE METRO-POLIS. Population 1871, 3,254,200.
January 5	—	—	1	1	3	5	April 6	—	3	—	—	5	8
" 12	2	2	1	1	3	9	" 13	2	3	—	—	4	9
" 19	—	3	1	—	1	5	" 20	2	2	—	2	2	8
" 26	1	2	—	1	2	6	" 27	1	3	2	1	4	11
February 2	3	4	—	—	2	9	May 4	1	2	—	—	7	10
" 9	2	3	—	1	4	10	" 11	—	5	2	1	1	9
" 16	1	1	—	—	3	5	" 18	—	4	1	3	4	12
" 23	3	2	—	—	4	9	" 25	3	11	—	1	5	20
March 2	1	4	—	2	1	8	June 1	2	11	—	2	2	17
" 9	1	4	—	—	2	7	" 8	1	5	1	5	4	16
" 16	2	2	—	1	1	6	" 15	2	1	1	—	4	8
" 23	1	5	—	2	5	13	" 22	3	2	1	1	5	12
" 30	2	4	1	4	1	12	" 29	3	1	1	—	2	7
Totals, 13 } weeks - }	19	36	4	13	32	104	Total, 13 } weeks - }	20	53	9	16	49	147

The disease prevalent in Kilburn and St. John's Wood has commonly received the name of diphtheria, or diphtheritic sore throat. Under the latter name have been included cases of all degrees of intensity; some very severe, some not severe, and some even so mild that their nature was rather inferred from their relation to other cases than from their own symptoms. These last cases, however, like the rest, may be taken to have been usually, if not always, examples of real diphtheria. It will be convenient that in this Report, which will have little concern with degrees of severity of the same complaint, that I should speak of the prevalent disease as "throat illness." From

information obtained from the 'above-mentioned sources, I am satisfied that in these localities hardly any cases can have occurred of throat illness that have not come to my knowledge. Certainly, the total of unknown cases (including a few where information has been purposely withheld by householders) can bear no such proportion of the known cases as in any degree to invalidate the conclusions of this Report. Particular inquiry has been made into the facts of 264 cases in 118 households, among which cases there have been 38 deaths.

The outbreak, in which middle-class families have necessarily suffered most (seeing that the district contains few but middle-class houses), has been limited in two ways,—

1. As regards area.
2. As regards time.

The two limitations have to be considered to some extent together.

Describing a circle of half a mile radius with its centre in the Abbey Road at the junction of Hampstead and Marylebone parishes (viz., at the corner of Springfield Road) an area is included having a population of some 15,000 persons living in 2,700 houses. I shall speak of this area as the "inner circle;" it was in this that the maximum incidence of the disease was experienced. Describing from the same centre a larger circle of one mile radius, a further area is included beyond the limits of the inner circle, having a population that cannot be exactly estimated, but which cannot be less than that of the inner circle itself. This I shall call the "outer ring." The inner circle scarcely extends at any point beyond the boundaries of the Hampstead and Marylebone parishes, but the outer ring comprises, besides parts of these parishes, portions of Willesden and Paddington sanitary districts.

Now within the inner circle there have occurred during the epidemic 230 cases of throat illness in 98 households, and in the outer ring a further 34 cases in 20 households during the same period, making the total before given. It will be seen that the incidence was very intensely upon the restricted area of the inner circle; the incidence on the outer ring having, however, been in excess over the incidence of the disease throughout the metropolis generally. Table II. shows the new attacks week by week within the inner circle and the outer ring respectively, from the beginning of March to mid June.

TABLE II.

Week ending	INNER CIRCLE.			OUTER RING.		
	Households newly invaded.	Persons newly attacked.	Deaths.	Households newly invaded.	Persons newly attacked.	Deaths.
March 9 - -	1	1	—	1	1	—
" 16 - -	4	6	—	1	6	—
" 23 - -	2	4	1	—	—	—
" 30 - -	4	4	3	1	2	—
April 6 - -	—	1	1	2	2	1
" 13 - -	—	1	—	2	3	—
" 20 - -	2	6	—	—	1	—
" 27 - -	5	8	—	1	2	—
May 4 - -	8	16	1	2	2	—
" 11 - -	7	20	1	—	—	—
" 18 - -	41	104	1	5	7	—
" 25 - -	14	35	13	1	2	1
June 1 - -	5	12	4	3	3	2
" 8 - -	3	7	3	—	2	4
" 15 - -	2	5	2	1	1	—
Totals in 15 weeks	98	230	30	20	34	8

The table gives the incidence of throat illness week by week throughout the whole epidemic period from early March to mid June; and it will be seen that out of a total of 118 invaded households no less than 78 got their first attacks during the four weeks ending May 25. The special incidence on these four weeks was even more marked in the case of the inner circle, where during that period no less than 70 households were newly invaded out of the 98 that were attacked during the epidemic. Nor was this all, for it will be observed that during the third week of May the newly invaded households bounded up to the very large number of 46 (41 of them in the inner circle)

against 7 in the preceding week. The fall was almost as sudden, namely, to 15 and 8 in the two succeeding weeks, and thenceforth the outbreak, as such, abruptly terminated without to any perceptible degree extending into the outer ring, or to the metropolis generally. Obviously in this history of the prevalence of throat illness there is question of some factor strongly circumscribed in area and operative during a very limited time.

The investigation of the cause of the outbreak will primarily consist in the identification, if possible, of this factor. From former inquiries into the prevalence of diphtheria, no such knowledge of the etiology of the disease has been gained as could enable the present investigation to proceed deductively by search after conditions known to be capable of producing the observed result. Hitherto, so far as I am aware, no conclusive evidence has been adduced of diphtheria being disseminated by the agency of water or of milk, nor has it been satisfactorily connected with sewer air or other foul emanations. All that previous research has justified us in affirming is that the disease has a power of spread from person to person, and has also a faculty of development out of an antecedent prevalence of throat illness, the diphtheritic character of which may not, until a certain stage of the prevalence has been reached, be affirmed. Any deductive application of this meagre knowledge cannot be expected to lead us far. In the present inquiry, I have carefully searched for antecedent throat illness, whether or not diphtheritic, in other people, to which the first sick person in the several households infected may by possibility have been exposed; indeed for exposure of these first sick persons to any common personal condition. There were very few instances in which the first person attacked in a house had been knowingly in any relation whatever with another person having any sort of throat illness, and these few instances need not be taken into account. Of unsuspected personal relations with previous cases, the only kind that appeared to deserve consideration was the possible operation of school attendance. Investigation into this and the above point led to the following results in 111 households thus dealt with:—

In 77, or 69·3 per cent. the first sufferer had neither had communication with any case of antecedent throat illness, nor had such person attended school within a period of one week before date of attack. In 24, or 21·6 per cent., the first sufferer had attended school within the period referred to. In 8, or 7·4 per cent., there had been opportunity more or less complete for the first sufferer acquiring infection from a pre-existing case. In 2, or 1·8 per cent., the first sufferer had opportunity of both sorts for acquiring infection. Any question, then, of direct infection from person to person, of a kind to account for the outbreak under review, may at once be set aside.

Passing on to other conditions, which, if not known to be capable of spreading diphtheria, are at least known to be generally unwholesome conditions, or to have been concerned in the spread of other diseases, the chance of some water contamination may be first considered; but it may be very summarily dismissed. The invaded houses, like the rest of the area, were almost exclusively supplied by the West Middlesex Company, the water of which is as good, perhaps, as any in London, and was supplied at the same period to extensive surrounding districts in which there was little, if any, diphtheria. No question arose of contamination in the local services of affected houses, and it may be affirmed that in comparatively few of the houses (the infected not differing from the non-infected in this respect) was there opportunity of pollution of water after its delivery from the main.

As to other unwholesome conditions in and about dwellings, with one exception they may all be set aside as either not existing, or not existing in any peculiar degree or with any special character, in the district attacked when this was compared with districts that escaped. Rarely have persons admitted the existence on their own premises of any sort of nuisance. Some few have complained of collections of refuse on waste land in preparation for building, or of collections of foul water in ponds in similar situations in their neighbourhood. In addition complaint has been made in a few instances of foul-smelling stables and cowsheds near to dwellings. Complaint as to waste-land nuisances has come from that part of Kilburn and South Hampstead immediately north of the London and North-western Railway, and doubtless there has been ground for objection to nuisance of such sort. But assuming that such nuisance has been of very intense character, and that it has had moreover capacity for inducing throat illness, it is difficult to explain the facts of the outbreak on the hypothesis that it has been operative. Dwellings in the immediate neighbourhood of these waste lands

can hardly be said to have suffered disproportionally to dwellings far removed from the nuisance complained of.

The one exception above made relates to sewers and drains of the infected area. Herein there were found conditions of defect of a nature liable to do injury to health, and very much localised in the particular area of the epidemic. The history is as follows:—

At the western extremity of Alexandra Road, St. John's Wood, two main sewers, 6 ft. $\times$ 5 ft. 6 ins. and 6 ft. $\times$ 5 ft. respectively, coalesce to form a single circular sewer, which for a course of 450 ft. has an average diameter of 4 ft. 6 ins.; afterwards this sewer expands to 7 ft. diameter. Of the two sewers thus undergoing constriction at their outlet, one drains a comparatively limited area to the northward—Kilburn Vale and neighbourhood; the other receives from the north and east contributory sewers from about one half the area of Hampstead parish, east of the Finchley Road, and in addition receives from the southward the Abbey Road sewer draining a large portion of St. John's Wood. The special sewage area thus constituted corresponds in its inhabited parts pretty closely to the area defined by the inner circle. Except small portions on the east and west confines, this sewage area occupies the whole of that circle, and though extending northwards into the outer ring, it has not in that region any considerable population. Altogether, of the 2,700 dwellings in the inner circle, this special sewage area comprises some 2,000. The sewers of this area are generally ill-ventilated. Openings at the street level are rare; such ventilation as is obtained being by means of street gullies, nominally but inefficiently trapped. There is no systematic flushing of these sewers. As regards private drainage, trapping of drain inlets within houses has commonly been relied on for securing dwellings against entrance of sewer air, adequate ventilation of house drains having been generally neglected. Of course there are exceptions (and among them not a few in households invaded by throat illness) where, in conjunction with trapping, care has been exercised in duly ventilating the house drainage. But too often the ventilation adopted has been restricted to a single ventilating orifice; and as regards trapping, kitchen and housemaid's sinks have frequently been merely provided with bell-traps. In addition wastepipes from cisterns and baths have been found in several instances to communicate directly with drains. In short, dwellings in this area, as in London generally, must be held to be commonly, under circumstances of unusual pressure within ill-ventilated sewers, very inefficiently protected against entrance into them of sewer air.

Under conditions of public sewerage and private drainage of the above sorts, the special area cannot have failed to have been repeatedly, if not continually, exposed to sewer and drain nuisances; for the liability of the main sewers to strangulation at their outfall under exceptional rainfall must have frequently conduced to extensive backing up of sewage and penning up of foul air within the ill-ventilated sewers, and hence to forcible expulsion of the pent-up sewer air by the way of unventilated house drains and inefficiently trapped orifices into the dwellings of the district. As a fact strangulation in the above sense, and of a serious sort, of these particular sewers at their outfall occurred as a result of the notable rainfall of 10th and 11th April last. On this occasion the surveyor of Hampstead Vestry has shown that the chief of the sewers referred to (that draining St. John's Wood and South Hampstead) usurped altogether the circular outfall sewer, retarding the flow from and even producing a back current in its companion sewer from the Kilburn Vale district, which subsequently was found partially silted up for a considerable distance. The most conspicuous result on this occasion seems to have been serious flooding of the basements of low-lying houses near Kilburn Station; and, in addition, rupture of a pipe sewer at a higher level in Priory Road occurred with further flooding of basements in that neighbourhood; but there is good ground for believing that mere flooding did not represent the whole mischief thus caused. Blocking of the main sewer outlet for this district to the extent indicated by the flooding must have caused immense pressure over a large area within the sewers, and sewer air can hardly have failed to have been driven out into dwellings over a large portion, if not over the whole, of the area served by these sewers. That something of this sort did take place there is abundant evidence, though such result did not generally attract notice. Clearly, if sewer air be by itself capable of causing throat illness, persons resident in the special sewage area must, as a result of the obstruction at the sewer outfall on 11th April, have been exposed beyond all persons resident in the district under consideration to special risk of attack by the disease.

The incidence of throat illness on the special sewage area, on the remainder of the inner circle, and on the outer ring is given in Table III.

TABLE III.

Week ending	Special Sewage Area. Houses, 2,000.	Adjoining Districts.	
		Inner Circle. Houses, 700.	Outer Ring. Houses, 2,700.
March 9 - -	1	—	1
" 16 - -	4	—	1
" 23 - -	2	—	—
" 30 - -	4	—	1
April 6 - -	—	—	2
" 13 - -	—	—	2
" 20 - -	1	1	—
" 27 - -	4	1	1
May 4 - -	6	2	2
" 11 - -	7	—	—
" 18 - -	38	3	5
" 25 - -	13	—	2
June 1 - -	3	3	2
" 8 - -	2	1	—
" 15 - -	1	1	1
Totals, 15 weeks -	86	12	20

It is thus seen that throughout the outbreak there has been a marked excess of incidence of throat illness on the special sewage area as compared with the rest of the district under consideration; that in the four weeks succeeding the date of the sewer obstruction there was a steady growth of incidence on the sewage area not shared by other parts of the affected district; and that in the fifth week from the above date there was an explosion of throat illness affecting the sewage area, while other parts of the district suffered little increase. These facts are expressed in the following table in rates per 1,000 households in the areas referred to:—

TABLE IV.

Periods.	Households per 1,000 attacked by Throat Illness.	
	Special Sewage Area. Houses, 2,000.	Other Parts of Infected District. Houses, 3,400.
Whole outbreak - -	43·0	9·2
Six weeks to date of sewer obstruction - -	5·5	2·0
Four weeks succeeding date of sewer obstruction - -	9·0	2·0
Fifth week from date of sewer obstruction - -	19·0	2·3
Rest of the outbreak - -	9·5	2·9

Further evidence in support of connection between incidence of throat illness and the sewerage arrangements is derived from the fact that in the special sewage area cases have had a tendency to group on short lines of sewers having dead ends. This has been the case in regard of Abbey Gardens, Marlborough Place, Blenheim Terrace, Clifton Hill West, Goldsmiths Gardens, Birchington Road, Canfield Road, &c. The same thing occurred in Upper Hamilton Terrace, which is also drained to the special sewers. In this terrace six households were invaded, while in Hamilton Terrace (its continuation to the southward), which is connected with other sewers, there was not a single case. Again, in or about St. George's Terrace, Kilburn, on the line of sewers subjected to actual flooding, a special incidence of throat illness occurred.

If this were all the evidence obtainable upon the facts of the outbreak, it would look indeed as if there were a real relation between the circumstances of the special sewage area and the incidence of the throat illness. It is true that the incidence upon the special sewage area, though intense, was not more than two and a half times as

intense as on the remainder of the inner circle (see Table III.), and a difficulty in accepting this explanation of the outbreak arises from the five weeks' interval between the occasion of the obstruction to the sewers and the outburst of throat illness, such interval being not easily reconciled with what is known of the incubation period of diphtheria. But still it may well be that the few days' incubation period commonly observed in cases of diphtheria due to direct infection by antecedent diphtheria is no measure of the period necessary for the development of this disease from a remoter first cause. It is conceivable in fact that, notwithstanding the interval observed, the relation suspected may have been real; indeed, unless other and completer explanation be forthcoming, it could not be disputed that the sudden obstruction of the sewers which has been described may in some obscure way have had to do with the subsequent great development of throat illness.

Looking at the history of the outbreak thus far then, it is not to be wondered at that popular opinion has ascribed it to the sewer defects of the district, and especially to the palpable sewer nuisances of April 11. And I do not pretend to deny that these conditions may have had some concern in the outbreak, though it will appear, when the whole story is told, that if they have held any place in its causation, they have held but a secondary and subordinate place.

The epidemic has now to be considered in its relation with milk supply. Milk came under suspicion during the great outburst of throat illness in May, Dr. Morton then observing that a very large proportion of the cases occurring in his practice were served with milk by one or other of two tradesmen, both of whom, he ascertained, obtained their milk supply from the same wholesale dealer. It will be seen in the sequel how far this surmise has proved to be well founded. But it may be well here to state explicitly that at the beginning of the inquiry I looked on the relation of the throat illness to milk supply as improbable. We have heretofore had no conclusive evidence of diphtheria disseminated along with milk, as in the case of enteric or scarlet fever, and it seemed to me essential that, before accepting a milk explanation of the outbreak, all other clues as to causation should be exhausted. So that, while detailed investigation of the milk circumstances of the district was being carried on *pari passu* with other inquiries, it was not until an advanced stage of the inquiry (in fact not until the sewer evidence had been accumulated) that additional and strongly corroborative evidence on the milk question was attained. Under the circumstances I do not propose to indicate the various stages of inquiry, but instead to give as briefly as may be the story of the milk and the evidence respecting it ultimately obtained.

Of the numerous sources whence the milk supply of the area of the outbreak has been derived, two wholesale milk businesses only require particular consideration. Both of them are in the hands of one proprietor, whom I will call Mr. X, and they are situated, the one, cowsheds (to be referred to as X¹), at Kilburn; and the other, a dairy farm (to be referred to as X²), at Muswell Hill. Although owned by the same person, these two milk businesses are, as regards employés, general administration, and milk-service, wholly distinct one from the other. As regards cows only, and to some extent cow food, have they, so far as I have been able to ascertain, any community of circumstance. Fresh cows are obtained in each instance from the same breeder in the country, and cows are, when occasion requires, subject to transference from one business to the other. Cow food, such as grains and meal, is obtained in each instance from the same sources, and hay is partly supplied to both places from the farm itself. At the period of the outbreak, X¹, the Kilburn cowsheds, afforded daily some 80 barn gallons of milk. Of this amount, 47 and 24 barn gallons, a constant quantity in each instance, were supplied respectively to Mr. A of Kilburn and Mr. B of St. John's Wood, and by them distributed mainly within the inner circle. Mr. A derived his whole supply and Mr. B part only of his supply from this source. The remainder of the total yield of X¹, a quantity varying day by day, but averaging about nine gallons daily, was supplied to and distributed by eight other retail dealers (Messrs. *c, d, e, &c.*, the small letters signifying their small concern in the affair), in Kilburn two, in Portland Town five, and near Dorset Square one. X², the dairy farm at Muswell Hill, afforded daily

SCHEME of Mr. X's MILK DISTRIBUTION.

Milk Supply derived from—					
Dairy X ¹ (yield about 80 gallons).			Dairy X ² (yield about 54 gallons).		
By Mr. A	-	47	By Mr. M	-	9
" B	-	24	" N	-	19
By Messrs. <i>c</i>	}	?	" O	-	10
" <i>d</i>			" P	-	2½
" <i>e</i>			" Q	-	13
" <i>&c.</i>					

The figures refer to barn gallons daily.
A, B, *c, d, e, M, N, O, P, Q*, indicate retailers, of whom, among those supplied from dairy X¹, *c, d, e, &c.* took only such balance of milk as remained after A and B had been supplied. Mr. A. derived his whole supply from Mr. X; the others part only of their supply.

some 50-60 barn gallons, distributed to and retailed by five tradesmen in five different localities as follows—Mr. M, Adelaide Road, nine barn gallons; Mr. N, Fortis Green, 19; Mr. O, West Islington, 10; Mr. P, Colney Hatch, $2\frac{1}{2}$; and Mr. Q, New End, Hampstead, 13 barn gallons. In addition, any milk remaining (an uncommon occurrence) after these tradesmen were served was got rid of (directly from this business) to the retail dealers in Portland Town, already referred to as among those obtaining milk under somewhat similar circumstances, though more regularly, from X¹ business. For convenience of reference most of the above facts are expressed in a tabular manner in the margin.

Now the milk supply of the circle within which occurred the greatest prevalence of throat illness, the "inner circle" of this Report, has been tolerably exactly ascertained, and for present purposes may be stated as follows:—

Households supplied by Mr. A	-	-	-	-	236	} = 2,700
" " Mr. B	-	-	-	-	237	
" " other milkmen (including Messrs.						
M, c, d, e, &c.)	-	-	-	-	2,227	

So that of the total milk supply of the inner circle about one fifth was from two retail dealers distributing the bulk of the milk from the X¹ wholesale business.

On the above several groups of milk consumers the incidence of throat illness, taken to mid June, when the outburst as such ceased, was extremely unequal. This will be apparent from the following figures:—

Of 236 households supplied by Mr. A,	37 were invaded, or	} 143 per 1,000
	156 per 1,000	
Of 237 " " Mr. B,	31 were invaded, or	
	130 per 1,000	
Of 2,227 " " other milkmen,	30 were invaded, or 13 " "	

A difference of incidence, namely, in proportion of 11 to 1 between the two sets of customers.

On investigating the relation of throat illness and milk supply in the outer ring similar evidence was forthcoming. The milk supply of this area, though not exactly ascertained, may be taken to have been as follows:—

Households supplied by Mr. A or B	-	-	-	some 100	} = 2,700.
" " other milkmen	-	-	-	" 2,600	

Here the incidence of throat illness on the two groups was 6 and 14; or 60 and 5 per 1,000 respectively; a difference, namely, of 12 to 1.

With reference to the evidence implicating the milk services of Messrs. A and B, and in view also of the fact that the places of business of these tradesmen were so situated within the inner circle as to tend very much to restrict their milk services to the special sewage area, it seemed desirable to examine, in a manner similar to that above adopted, the relation of throat illness and milk service within the special sewage area itself. This being done, gave:—

Households supplied by Mr. A or B	-	-	-	430	} = 2,300.
" " other milkmen	-	-	-	1,870	

Thus Messrs. A and B furnished less than a quarter, and other milkmen more than three quarters of the total milk supply of this area.

And the incidence of throat illness on these two groups was—

Of 430 households supplied by Messrs. A and B,	64 were invaded, or 148 per 1,000.
" 1,870 " " other milkmen	22 " 11 " "

or a difference of 13 to 1. So that in this special sewage area, where milk consumers of both sorts were alike exposed to the same influence of sewers, we have an inequality of incidence of throat illness on the two groups of customers even greater than that observed in regard of similar groups in the inner circle and in the outer ring. This exceptional incidence in the special sewage area of throat illness on customers of Messrs. A and B is further illustrated in the following table:—

TABLE V.

Locality.	Total House-holds.	House-holds invaded.	Of Total House-holds there were supplied by	Of House-holds so supplied there were invaded	Locality.	Total House-holds.	House-holds invaded.	Of Total House-holds there were supplied by	Of House-holds so supplied there were invaded
Abbey Lane -	14	1	A 3	1	Marlborough Place.	18	3	B 4	3
Abercorn Place -	35	2	B 2	1	Quex Road -	13	1	A 3	1
Birchington Road	11	3	{ A 2 B 2	1 } = 3 2	St. John's Place	3	1	B 1	1
Brunswick Villas	5	1	B 1	1	Upper Hamilton Terrace.	35	6	{ A 1 B 9	1 } = 5 4
Carfield Road -	5	2	A 2	2	Upton Road -	8	1	A 3	1
Clifton Hill -	114	5	A 9	3	Alexandra Road	195	8	A 15	5
Greville Place -	21	1	A 5	1					
Holtham Road -	17	1	A 1	1					

There is now seen in the facts of the milk supply of the special sewage area a reason, apart from any question of sewer circumstances, for the special incidence of throat illness therein observed.

On proceeding to examine the incidence of the throat illness as regards age, some further facts not inconsistent with milk causation of the outbreak are obtained. These are given in the following table :—

TABLE VI.

FACTS as to AGE of 233 (out of the 264) Cases of THROAT ILLNESS investigated in Kilburn and St. John's Wood.

	All Ages -	233.
0—1 -	2, or	0·8 per cent. of 233.
1—3 -	21, „	9·0 „ „ „
3—12 -	124, „	53·2 „ „ „
12—20 -	31, „	13·4 „ „ „
20+ -	55, „	23·6 „ „ „

It is thus seen that children, notably children at ages 3–12 years, have especially suffered from throat illness. And some such incidence might have been anticipated in an outbreak due to milk causation ; for children, as essentially the milk drinkers in their families, would under such circumstances be especially prone to suffer infection. But the facts respecting age incidence here observed must not be regarded as necessarily significant of infected milk. In other outbreaks of diphtheria, where milk has not come in question, children at ages 3–12 years have especially suffered, while infants under 3 and persons over 12 years have suffered proportionally very slightly.

It becomes necessary now to investigate the relation as regards time between the incidence of throat illness and milk service. This may be dealt with by classing together the areas hitherto considered separately, and by contrasting the time incidence of the disease on households supplied by retailers other than A or B with that affecting customers of these tradesmen, which has been done in the following tables VII. and VIII.

TABLE VII.

SHOWING the NUMBER of HOUSEHOLDS invaded Week by Week in each GROUP referred to.

—	March 9.	March 16.	March 23.	March 30.	April 6.	April 13.	April 20.	April 27.	May 4.	May 11.	May 18.	May 25.	June 1.	June 8.	June 15.
Households supplied by retailers other than Mr. A or Mr. B -	1	5	2	5	2	2	1	2	4	1	6	4	5	2	2
Households supplied by Messrs. A or B only -	1	—	—	—	—	—	1	4	6	6	40	11	3	1	1

TABLE VIII.

SHOWING the RATES of INVASION per 1,000 HOUSEHOLDS in each GROUP referred to.

—	March 9.	March 16.	March 23.	March 30.	April 6.	April 13.	April 20.	April 27.	May 4.	May 11.	May 18.	May 25.	June 1.	June 8.	June 15.
Households supplied by retailers other than Mr. A or Mr. B	.2	1.0	.4	1.0	.4	.4	.2	.4	.8	.2	1.2	.8	1.0	.4	.4
Households supplied by Messrs. A or B only	1.7	.0	.0	.0	.0	.0	1.7	7.0	10.5	10.5	70.1	19.2	5.2	1.7	1.7

It thus appears that not only have customers of Messrs. A and B suffered, as has been already ascertained, relatively and actually in excess of other people, but that these persons have borne almost the whole brunt of that outburst of throat illness which first attracted attention to the district, and which has been locally referred to sewer causation. From almost complete immunity during the five weeks ending April 13, customers of Messrs. A and B commenced to suffer in rapidly increasing ratio until in mid May they were invaded in one week at a rate of 70 per 1,000 households ; after that date their rate of attack declined even more rapidly than it had arisen, and by mid June had become almost nil. It will be observed, however, that apart from the throat illness affecting customers of Messrs. A and B, there was throat illness in the area under consideration before, during, and after the outburst referred to. Hence whatever may have been the influence of Messrs. A and B's milk in the causation of the outburst, such milk cannot be credited with all the mischief which has occurred ; especially, it must be acquitted of the introduction and early maintenance of the disease in the district.

This other throat illness in the district during the period under investigation, affected 44 households ; 17 of which obtained their milk from retailers (other than Mr. A or Mr. B) supplied in part by Mr. X, and 27 from wholly different sources. Further, of the households supplied by retailers who had relations with Mr. X, 13 obtained their milk from Mr. M, who derived such part of his total milk as he obtained from Mr. X, not from the X¹ business at Kilburn, but from the X² business at Muswell Hill. The facts are as follows :—

TABLE IX.

FACTS as to THROAT ILLNESS in HOUSEHOLDS not supplied by Mr. A. or Mr. B.

Households obtaining Milk from	Period antecedent to Main Outburst.									Period corresponding to Main Outburst.							
	Mar. 9.	Mar. 16.	Mar. 23.	Mar. 30.	April 6.	April 13.	April 20.	April 27.	House- holds invaded in Period.	May 4.	May 11.	May 18.	May 25.	June 1.	June 8.	June 15.	House- holds invaded in Period.
X sources { Messrs. c, d, e, &c. (X ¹ busi- ness). Mr. M (X ² busi- ness).	—	—	—	—	—	—	—	1	1	—	—	1	1	1	—	—	8
	1	2	1	4	2	1	—	1	12	1	—	—	—	—	—	—	1
Sources other than X . . .	—	3	1	1	—	1	1	—	7	3	1	5	3	4	2	2	20
Totals	1	5	2	5	2	2	1	2	20	4	1	6	4	5	2	2	24

Here may be observed, apart from Messrs. A and B, a certain moderate prevalence of throat illness over the district. Looking at the second half of the table, we find the distribution of disease, apart from those two retailers, to have been as nearly as possible what might have been expected if milk supplies were not in question, for the figures 3, 1, and 20 are roughly proportional to the number of families getting their milk from one and another source. But now, having got this rough standard, let us look at the first half of the table, which deals with the *period antecedent to the main outburst*. A very different distribution is here seen. At this time there was less throat illness scattered about, but such as there was fell with exceptionally intense incidence upon the families who consumed milk distributed by Mr. M, in which was included a quantity, amounting to nine barn gallons daily, derived from Mr. X's Muswell Hill farm. Now *this exceptional incidence was the earliest of any special incidence* of throat illness anywhere in the district, and special interest therefore attaches to it.

In this connexion it becomes necessary to advert to Mr. X's Muswell Hill business, from which Mr. M above referred to derived part of his supply. Muswell Hill milk,

within the area hitherto dealt with, was retailed only by Mr. M; and though not connected with the great outburst herein of throat illness, was nevertheless associated, in regard of Mr. M's customers, with a large amount of that throat illness in the district which preceded the great outburst among customers of retailers supplied with milk from the Kilburn business. A suspicion is thus raised whether Muswell Hill milk may not, like Kilburn milk, have been causative of throat illness, though operating in a different manner; and further whether it may not have been concerned in the inception and early maintenance of the disease in the district in question. Here it may be noted that although Mr. M's business is as large and his customers as numerous as Mr. A's or Mr. B's, the amount of milk received by him from Mr. X's Muswell Hill business has been small, nine barn gallons only daily. This milk has, from the situation of Mr. M's business, been distributed quite as much in the outer ring as in the inner circle; and the throat illness associated with this milk service has not been confined to any particular part of the district, but households invaded have been (seven in the inner circle and six in the outer ring) distributed over the whole area of his supply. The suspicion thus raised derives support from the facts, so far as I have been able to ascertain them, with regard to other retailers obtaining milk from the Muswell Hill business.

Fortis Green and neighbourhood, the area of distribution by Mr. N of 19 barn gallons of Muswell Hill milk.—Hereabouts a serious prevalence of diphtheria and throat illness excited in April last considerable attention and no little alarm. Locally the outbreak was attributed (as was the outbreak in Kilburn and St. John's Wood) to sewer emanations; but the result of an inquiry by the Medical Officer of Health of the district did not support this theory. This gentleman found that the diphtheria had been pretty equally distributed over a district served by "three perfectly distinct and unconnected lines of public sewers." Subsequently, by personal inquiry in the district, conducted broadly on lines similar to those adopted in the Kilburn inquiry, I was able to satisfy myself that for the above and for other reasons sewers might here be excluded; and that other ordinarily ascribed causes of diphtheria, such as water supply, personal communication of the healthy with the sick, and the like, might in the majority of instances also be set aside. But the circumstances in regard of milk service were at least suspicious. Milk, I found, had been distributed to the several hundred houses of the district mainly by two retailers residing near together; one, Mr. N, who obtained a considerable proportion of his total supply from Mr. X's Muswell Hill business, the other, a tradesman whose supply was altogether different. In the following table are recorded the principal facts of the outbreak.

TABLE X.
THROAT ILLNESS in FORTIS GREEN and NEIGHBOURHOOD.

Periods.	Localities invaded.	House-holds invaded.	Aggregate Cases.	Invaded Households supplied with Milk by		Remarks.
				Mr. N.	Other Milkmen.	
Week ending March 16	Tatterdown Lane - -	1	4	1	—	
	Main Road, Fortis Green -	2	4	2	—	
	Eastern Road, Fortis Green -	1	1	1	—	
	Southern Road, Fortis Green	1	2	1	—	
Week ending March 23	Western Road, Fortis Green	1	2	1	—	
	Southern Road, Fortis Green	1	3	1	—	
	Page's Lane, Muswell Hill -	1	2	1	—	
	St. James' Lane, Muswell Hill	2	*2	—	2	* Two brothers living next door to one another. The first attacked worked for Mr. N.
Week ending March 30	Tatterdown Lane - -	1	2	1	—	
	Colney Hatch Lane - -	2	3	2	—	
	St. James' Lane - -	2	4	1	†1	† Lived next door to youth employed by Mr. N.
	Southwood Lane - -	1	2	1	—	
Week ending April to middle of month	Belle Vue - -	1	1	1	—	
	Main Road, Fortis Green -	2	4	2	—	
	St. James' Lane - -	1	1	—	1	
	Southern Road, Fortis Green	1	1	1	—	
Week ending April to end of month and May	Southwood Road - -	1	3	—	1†	
	Southwood Road, Muswell Hill	2	2	—	2	
	Tatterdown Lane - -	2	5	1	1	
June -	St. James' Lane - -	1	1	—	1	
Totals -	10	27	49	18	9	

† Postscript, Feb. 1879.—I have since learned that this household, up to the date of its invasion by throat illness, obtained its milk supply through Mr. N. from the Muswell Hill farm. The figure 1 should therefore have been placed in the previous column, and the totals would then become 19 and 8 instead of 18 and 9.—W. II. P.

It will be observed that up to June, of 27 households here invaded, 18 obtained their milk supply from Mr. N; and further, that of 17 households invaded during the first three weeks of the outbreak, all but three were so supplied. And these three exceptions are in their way noteworthy; the first was a youth employed by Mr. N in his milk business, but living in St. James' Lane; the second was a brother to this youth, living in a separate household near at hand; and the third was a girl living in a house next door to that in which the youth himself resided.

By itself, the evidence tending to implicate the Muswell Hill milk that is afforded by examination of the circumstances of throat illness in and about Fortis Green, is not, it may be admitted, of very great strength. But taken in conjunction with that adduced respecting similar association at the same time of throat illness with the milk supply (partly derived from Mr. X's Muswell Hill business) of Mr. M in St. John's Wood, it acquires much additional force. The facts that need to be insisted on are as follows:—In two localities so widely separated and so utterly differently circumstanced, except in this one matter of X's milk service, as St. John's Wood and Fortis Green, throat illness attacked, almost simultaneously, customers of retailers supplying the particular milk; continued to attack such persons with similar but moderate force for several weeks; and then, again simultaneously in both places, ceased to attack them. It is quite true that there was no "outburst" at either place, as there was later on at Kilburn, or as has been found to occur in certain outbreaks of enteric fever related to milk supply; but this is no reason for regarding Muswell Hill milk as having been unconcerned with the results observed. It may well be that "outbursts" of illness are not the sole expression of disease due to infected milk, and that here we have an instance. Such evidence as I have been able to procure respecting diphtheria during the period in question in localities where Messrs. O, P, and Q (also obtaining part of their milk from Muswell Hill) had their businesses, is to the following effect:—

(a.) *West Islington*, the area of distribution by Mr. O of 10 barn gallons of Mr. X's Muswell Hill milk.—For this district Dr. Tidy has supplied me with the following particulars respecting certain cases of diphtheria, these being all that came under his notice in this thickly populated district during March and April:—

TABLE XI.

HOUSEHOLDS fatally attacked by DIPHTHERIA in WEST ISLINGTON in March and April 1878.

Periods.	Localities invaded.	Households invaded.	Aggregate Cases.	Deaths.	Households invaded supplied with Milk by	
					Mr. O.	Other Milkmen.
Week ending March 23	Brook Road, Junction Road.	1	1	1	1	—
	Hargrove Road, Junction Road.	1	4	1	1	—
	Windermere Road, Upper Holloway.	1	1	1	1	—
Totals - -	3	3	6	3	3	—

(b.) *Colney Hatch*, the area of distribution by Mr. P of 2½ gallons of Mr. X's Muswell Hill milk.—For this locality Dr. Saunders has furnished me with information as follows:—

TABLE XII.

DIPHTHERIA in COLNEY HATCH.

Date.	Localities invaded.	Households invaded.	Aggregate Cases.	Deaths.	Invaded Households supplied with Milk by	
					Mr. P.	Other Milkmen.
April 3 - -	Sydney Road, Colney Hatch - -	1	1	1	1	—
" 3 - -	Sussex Terrace, " - -	1	1	1	—	1
" 8 - -	Alexandra Road, " - -	1	1	1	1	—
" 8 - -	Sydney Road, " - -	1	2	2	1	—
May 7 - -	Sussex Terrace, " - -	1	2	1	1	—
" 20 - -	Cromwell Road, " - -	1	1	1	—	1
Totals -	4	6	8	7	4	2

(c.) *New End, Hampstead*, the area of distribution by Mr. Q of 13 barn gallons of Mr. X's Muswell Hill milk.—In this neighbourhood, a highly populous one, I have not, in view of the other evidence, done more than ascertain that the only households (two) fatally invaded in March obtained, both of them, milk from Mr. Q.

The very similar incidence of throat illness on customers of retailers dealing in Mr. X's Muswell Hill milk, observed in places so distant from each other as the above, and separated, some of them, by tracts of inhabited districts in which no diphtheria was heard of, affords, I am disposed to think, strong corroborative evidence of the conclusion drawn from study of throat illness associated with the milk services of Messrs. M and N, viz., that the milk supplied to retailers by Mr. X from his Muswell Hill business, was in March and April an essential factor in the causation of the disease. Now it has been already shown that milk supplied to retailers (Messrs. A, B, c, d, e, &c.) by Mr. X from his Kilburn business, was in May and June similarly, though much more seriously, effective in producing throat illness. Hence it would seem that there has been at Mr. X's Muswell Hill business an influence causative of milk infection beginning to be operative in March, and ceasing to be so in April; while there has been at his Kilburn business an influence potent for the same result, though more intense in its effects, commencing in April and ceasing to be operative in June.

Such is the story of the outbreak, and its main facts may be summed up thus: (1.) Mr. X's milk, whether from Muswell Hill or from Kilburn, and in whatever locality distributed, has conveyed to customers of retailers distributing it throat illness. (2.) In regard of each business (Muswell Hill or Kilburn) the above relation of milk service to throat illness was observed for a limited period only, that period beginning for one business only about the time that it ceased for the other.

As to means whereby the milk became infected.

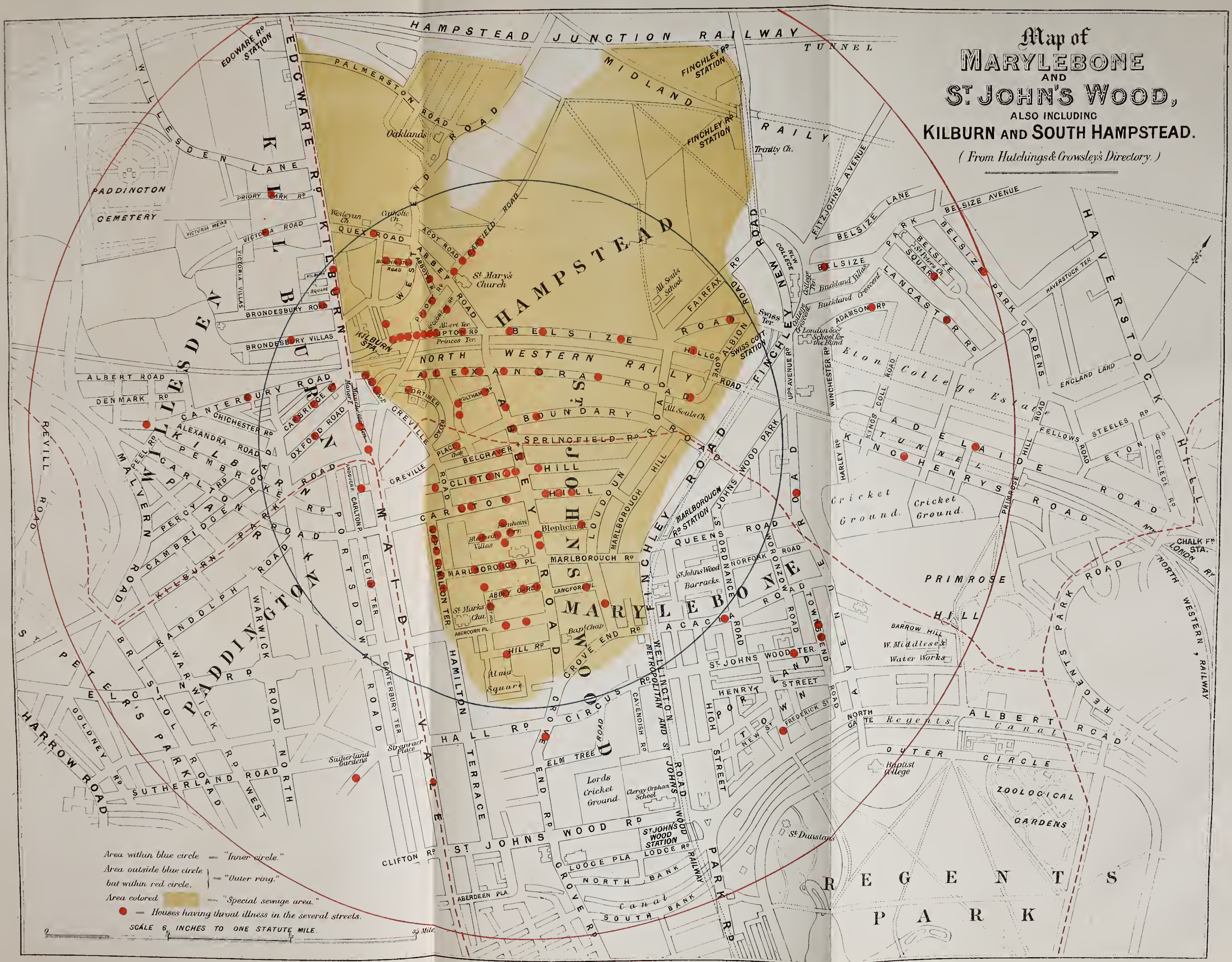
In view of the evidence above given it became of course my duty to institute investigation of the way or ways in which the milk, whether at Muswell Hill or at Kilburn, could have become specifically contaminated. Herein, in regard of methods by which milk has been known or has been suspected to have been infected, exact inquiry, from obscurity of the subject, has necessarily been limited. Its results may be dealt with as follows:—

1. *Infection after milking*.—Infective matters contained in water, in refuse on the premises, or in air, need to be considered.

(a.) As to water and other agents whereby dangerous contamination of milk utensils, and consequently of milk itself, may have been effected.—The water in use for dairy purposes at Muswell Hill is procured from the well affording the domestic supply of the farmhouse; that in similar use at Kilburn is from the supply of the West Middlesex Water Company. The well at the Muswell Hill farm cannot, it is true, be pronounced absolutely secure from foul soakage, and it is therefore possible that water from it, though in constant use by the family at the farm without ill-result, may, in combination with the milk, have been capable of developing infective property in that fluid. But as regards the water at the Kilburn business the case is altogether different. As already stated, it is West Middlesex water, and as to its good quality on delivery by the company there is no question; while as to possible danger to the water as stored on the Kilburn premises no question need arise. For, of the 10 retailers obtaining milk from the Kilburn business, Messrs. A, B, and another tradesman fetched their milk in their own churns, which churns were in each instance habitually cleansed at their own place of business. The seven other retailers (d, e, f, &c.) had their milk delivered to them in Mr. X's own churns, which were invariably cleansed at the Kilburn place of business. Now, Messrs. A and B had, as has been seen, among their customers a very large proportion of households invaded, while other retailers supplied with milk from the same business, but in Mr. X's own churns, had among their customers very few invaded households. Thus milk retailed by Messrs. A and B having a minimum chance (that arising from rinsing, before and after milking, of pails into which cows were milked) of fouling by the Kilburn dairy water, was associated with a maximum of throat illness; while milk retailed by other dealers having a maximum chance of such fouling was associated with a minimum of throat illness. There can be little doubt, then, that water may be set aside as inoperative.

As to other agents, such as soil, refuse, litter, &c., whereby, through carelessness of milkers or others, the milk utensils might have been coarsely fouled, there is not much to be said. Such matters existed at both places (as indeed was inevitable in regard of stall-fed cows); but no evidence was obtainable suggestive of human infection of

Map of MARYLEBONE AND ST JOHN'S WOOD, ALSO INCLUDING KILBURN AND SOUTH HAMPSTEAD. (From Hutchings & Growsley's Directory.)



Area within blue circle = "Inner circle."
 Area outside blue circle but within red circle. = "Outer ring."
 Area colored yellow = "Special sewage area."
 • = Houses having throat illness in the several streets.
 SCALE 6 INCHES TO ONE STATUTE MILE.

matters of this sort; nor was there in the method (which I viewed) of dealing with milk utensils any suggestion of common fouling by such matters.

(b.) As to air along with which milk may have absorbed infectious matter.—This question of air fouling could scarcely assume practical significance unless it could be shown that contamination of air at either place by specific infection of diphtheria could have occurred. No evidence whatever was forthcoming of any such contamination at either place. At neither, it is most positively affirmed, has diphtheria or throat illness of any sort occurred during the present year among families resident on the premises, or among persons (or their families) employed among the cows or in the dairy. Nor could human infectious disease (if it had existed) have readily been transferred from servants at one place to servants at the other place. The two businesses are many miles apart, and no interchange of servants has, it is asserted, occurred, the staff at each place being wholly distinct from the staff at the other. And further, at neither place has cream or butter, objects for which milk is commonly allowed to stand for many hours in a dairy, been included in the business; milk and milk alone has been in question, and this, almost as soon as drawn from the cow, has been habitually quickly despatched from the premises.

2. *Infection during the process of milking.*—Under these circumstances milk can only have been *humanly** infected at the hands or persons of milkers suffering from diphtheria or allied throat illness. But at neither place have milkers had (as afore-said) any infectious illness. Again, for an explanation of this sort of the facts as regards place and time of the throat illness associated with the milk, there is required, not a single case that might have been overlooked, but a succession, first at one place, then at the other, of infected persons during a considerable period of time; and it seems incredible that human cases in number necessary for such repeated and sustained infection of milk as seems to have occurred could have existed to have left behind them no trace of their occurrence. One other consideration remains which requires reference under this heading. It is this. Foul matters, including cow excrements, accumulated on the floor of buildings in which cows are kept, might during the recumbent position of cows have soiled the udder and teats, and hence have been, during the act of milking, transferred to the milk itself,—an accident much more likely to occur to stall-fed cows than to cows at pasture. As to danger (if any) to milk from fouling in such sort by matters non-excremental in their nature, we have no means of judging; but in regard of cow excrement itself, the subject seems (from analogy) different. Herein there *may*, under circumstances such as are referred to, have been risk of *specific* fouling of milk by particular cows suffering, whether recognised or not, from specific disease. The question thus arising (so far as I know, a new one) is part of the larger question which follows.

To whatever extent, namely, the foregoing reasoning has been valid, it will have led, as by a process of exclusion, to the surmise that actual cow conditions capable of affecting directly or indirectly the milk, may have brought about the result observed. Moreover, if value is to be attached to the sequence I before noted as to the date of infectiveness of milk derived from the Muswell Hill and Kilburn businesses, such community of condition as can be found between the Muswell Hill and Kilburn businesses, and such sequence as may have thence arisen in the circumstances of one or the other business, is community of ownership, community of cow food, and community in a limited sense of cows themselves. It will be observed that the fact of the two places of business having one owner, a prominent but apparently unimportant feature up to this stage of the investigation, obtains in this view some probable significance. For it has regulated the *food* of cows and the *reception* and *removal* of cows at each place, and the *transference* of cows from one place to the other; circumstances which so far as they may have influenced the condition or health of cows at each place at any given time, might have an important bearing on the question of causation of the throat illness. Accordingly inquiry has been made in the above directions, and though the result will be negative, a brief statement of the evidence may be given.

(a.) *Cow food.*—For both places “middlings” (meal) grains and hay have been obtained in each instance from the same source. For each place green food and roots have been obtained from different sources. At neither has raw sewage-grown grass been used as cow food. As to the several foods which have been common to cows at the two places, there is not in regard of any one of them evidence as to deleterious effect on cows so fed. But it may be noted, as possibly having significance for other inquirers, that the grains have in bulk been apt (as grains are apt) to undergo fer-

* Searlatinal infection is believed to have been communicated to milk during the act of milking by persons the skin of whose hands has been peeling during convalescence from that disease.

mentative or putrefactive change, or even to become "fly-blown." Moreover part of the hay has been supplied from the Muswell Hill farm, from certain low-lying meadows which, at particular seasons of the year, are irrigated with Hornsey sewage. It should, however, be mentioned that during the present year none of the Muswell Hill cows were grazed on that farm until after hay harvest.

(b.) *As to movements of cows.*—At both places the cows have been habitually and for a length of time obtained as required from a single cow breeder in the country. The number at each place has, of course, varied from time to time according to the requirements of business; but it may be taken as one of the essential features of a milk business pure and simple that constant change of cows has been required. To be profitable cows must be in full milk, and thus as soon as they begin to "dry off," they are got rid of and their place supplied by others. As an instance of the amount of change of this sort required in a considerable business, it may be mentioned in regard of one of the above businesses that during the three months ended in May last, 29 fresh cows were received, and about an equal number got rid of. Of these 29 fresh cows, 25 had already calved, and 4 had yet to calve at the date of their reception by Mr. X. As to transference of cows from one place of business to the other, this is admittedly an occasional occurrence, though it is one of which no book records are kept. Transference of cows from Muswell Hill to Kilburn during the period of the outbreak is not remembered to have occurred.

(c.) *As to health of cows.*—It is affirmed that at neither place has serious illness of cows occurred during the present year; and that certainly there has not been any recognised infectious illness among the cows. But this affirmation does not exclude (nor was it intended to exclude) occurrence among cows of "cold" or other minor ailment.

It is a matter of great regret to me to be obliged to present a report, which, while attributing to milk the outbreak I was directed to investigate, is negative as to the way or ways in which that milk became infective. This may be partly due to the complexity of the conditions requiring investigation, and to the lapse of time between the operation of the cause of the throat illness and the date of commencement of the inquiry. But there are indications that, had investigation been possible concurrently with the initiation, maintenance, and decline of operation at each place of this cause, the result might have been different. Any speculative explanations, however, that may have occurred to me are, I feel, beyond the scope of this report.

W. H. POWER.

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